ENERGY AND EXERGY ANALYSIS OF A DI-DIESEL ENGINE RUN WITH DIESEL - BIO LIQUID BLENDS

ICAER-2007

T.Ashokkumar, Dr.R.Chandramouli, D.Shanmugasundaram, T.K.Kandavel, Dr. K.Murugu Mohan Kumar

School of Mechanical Engineering.,
SASTRA University.,
Thanjavur- 613 402 Tamilnau.

I C A E R - 2 0 0 7

- Hiroshi Taniguchi, Kunihiko Mouri, Takefumi Nakahara, Norio Arai *(2005)* Exergy analysis on combustion and energy conversion processes.. *Energy 30 111-117*
- Jerald A, Caton.(2000) A review of investigations using the Second Law of Thermodynamics to Study Internal Combustion Engines. *SAE TECHNICAL PAPER SERIES 2000-01-1081.*
- Jerald A, Caton (2000) On the destruction of availability (exergy) due to combustion process- with specific application to internal-combustion engines. – *Energy*, 25 1097-1117

ICAER-2007

- London.A.L *(1992)* Economics and the second law: An engineering view and methodology. Int.J.Heat Mass transfer *vol. 25 No.6 pp743-75.*
- Mehmet Kopac and Lutfi Kokturk (2005).Determination of optimum speed of an internal combustion engine by exergy analysis. *Int. J. Energy vol. 2 No. 1, pp40-54*
- Najem. N.M.AL and J.M.Diab (*1992)* Energy-Exergy analysis of a diesel engine. *Heat Recovery System & CHP Vol. 12, No.6,pp525-529.*

Need to study Exergy :

- Exergy, more than energy, is a measure of economic value
- Better distribution of cost possible through Exergy
- Exergy, not energy, is the commodity of value in systems
- Exergy is the true reflection of irreversibility of real systems
- Exergy balance is more realistic – economically and thermodynamically than energy balance

T.Ashokkumar, Dr.R.Chandramouli, D.Shanmugasundaram, T.K.Kandavel,Dr. K.Murugu Mohan Kumar SASTRA University Thanjavur

- EXERGY – A measure of work potential
- The increased awareness of fast depletion of world's Energy resources - cause for concern - drastic measures needed to eliminate waste.
- A closer look at the energy conversion devices needed and developing new techniques for better utilisation of the existing limited resources – improving the effectiveness of systems and devices

- EXERGY – A measure of work potential

Limitations of existing method of Energy balance:

- The first law of thermodynamics deals merely with the quantity of energy and is limited in its approach
- This law merely serves as a necessary tool for the book keeping of energy during a process and does not deal with quality of energy

- EXERGY – A measure of work potential

- The **II Law** however deals with the quality of energy.
- It is concerned with the degradation of energy during a process, the entropy generation and the lost opportunities to do work and it offers opportunities for improvement.
- It has also proved to be a very powerful tool in the optimization of complex thermodynamics systems

- EXERGY (AVAILABILITY)

  Exergy - definition

- It is the maximum useful work that could be obtained from a system at a given state in a specified environment.
- It is also the useful work potential of a given amount of energy at some specified state.
- Exergy is also called Availability or Available Energy

- EXERGY (AVAILABILITY)

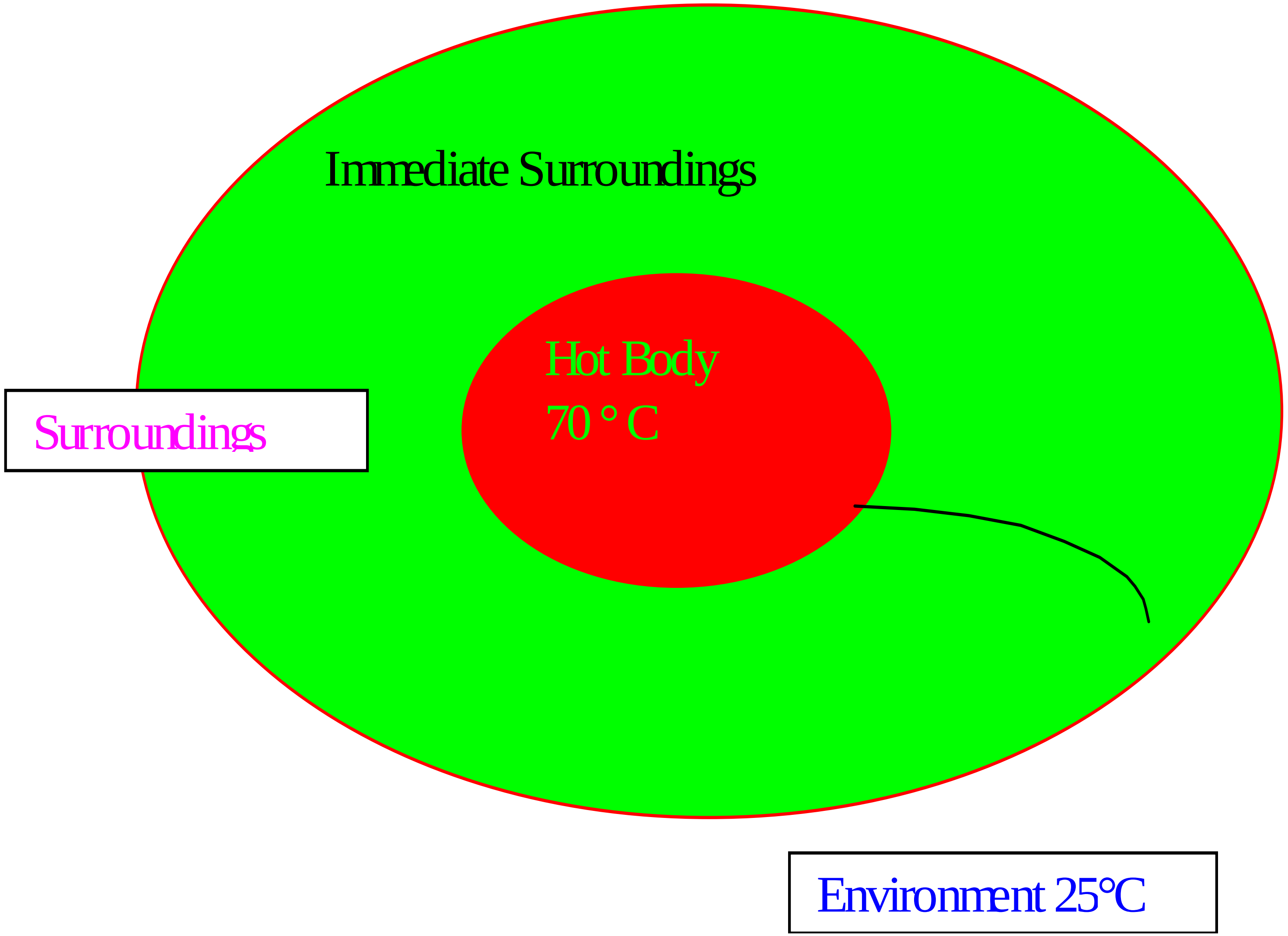
- Work done during a process depends on the initial state, the final state and the process.

W = f (initial state , process path, final state)

- EXERGY (AVAILABILITY)
- The work output is maximized when the process between two specified state is executed in a reversible manner.
- The system must be in the dead state at the end of the process to maximize the work output.
- A system is said to be in the dead state when it is in thermodynamic equilibrium with the environment.

- Surroundings: Every thing outside the system boundaries .
- Immediate surroundings: Portion of the surroundings that is affected by the process.
- Environment: Region beyond the immediate surroundings whose properties are not affected by the process at any point.
- Exergy is a property of the system – environment combination

T.Ashokkumar, Dr.R.Chandramouli, D.Shanmugasundaram, T.K.Kandavel,Dr. K.Murugu Mohan Kumar SASTRA University Thanjavur


Immediate Surroundings
Hot Body
70 ° C
Surroundings
Environment 25°C

- EXERGY TRANSFER FROM A FURNACE.

- Consider a large furnace that can supply heat at a temperature of 1100 K at a steady rate of 3165 kW. The environment temperature is 298K .
- The maximum theoretical efficiency or reversible efficiency is = $(T_H - T_L)/T_H$

$$= 1 - (298/1100)$$

$$= 0.729 \quad (\text{i.e. } 72.9\ \%)$$

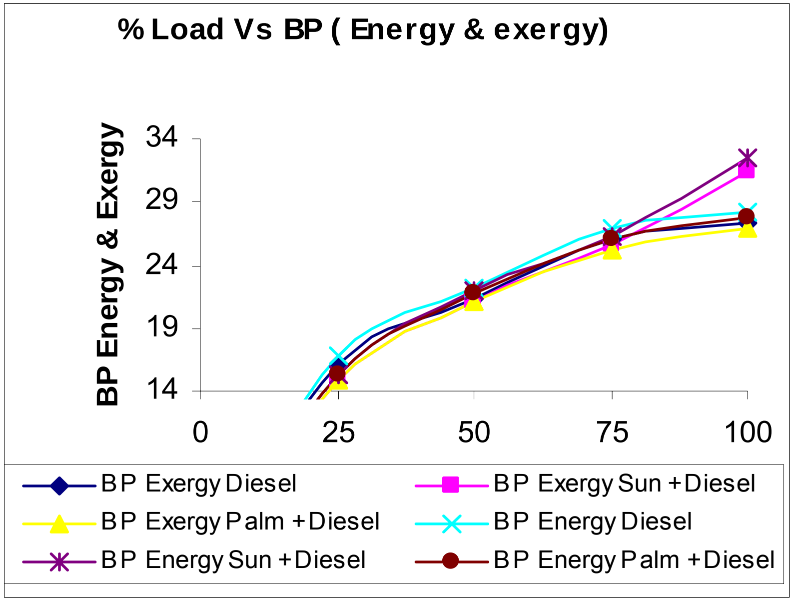
$$W_{max} = 0.729 \times 3165$$

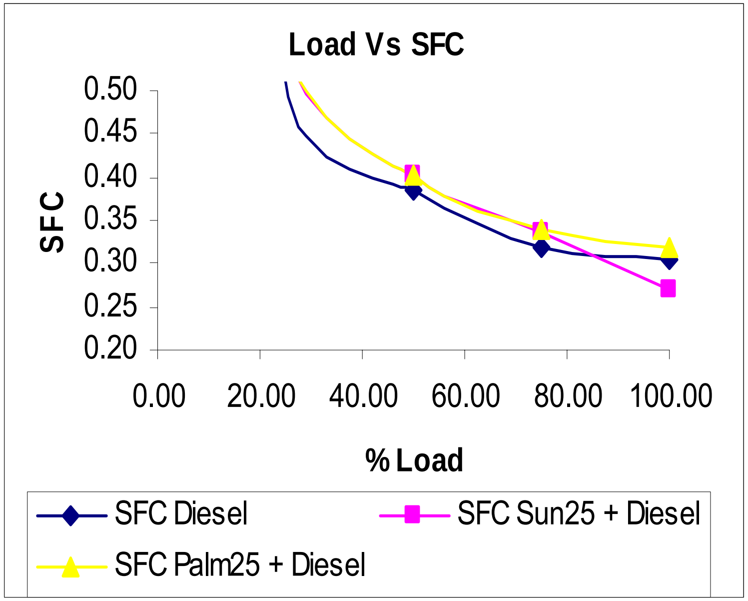
$$= 2307\ \text{kW.}$$

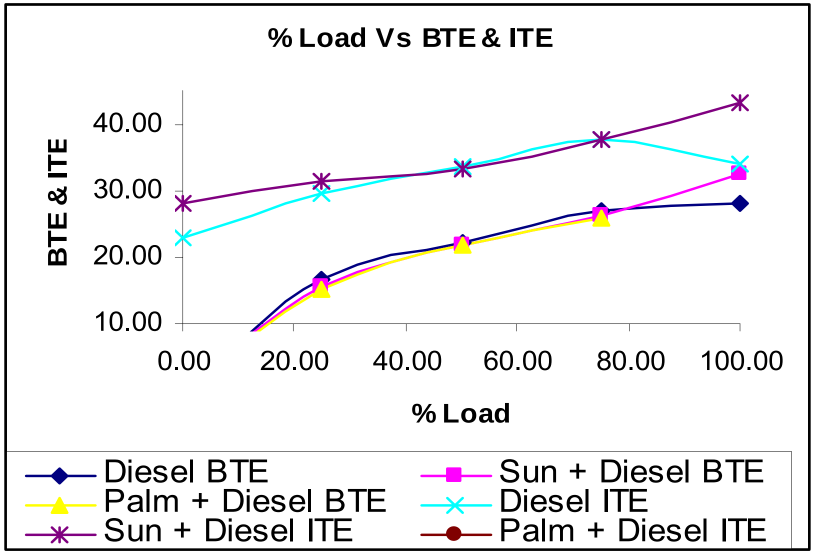
I C A E R - 2 0 0 7

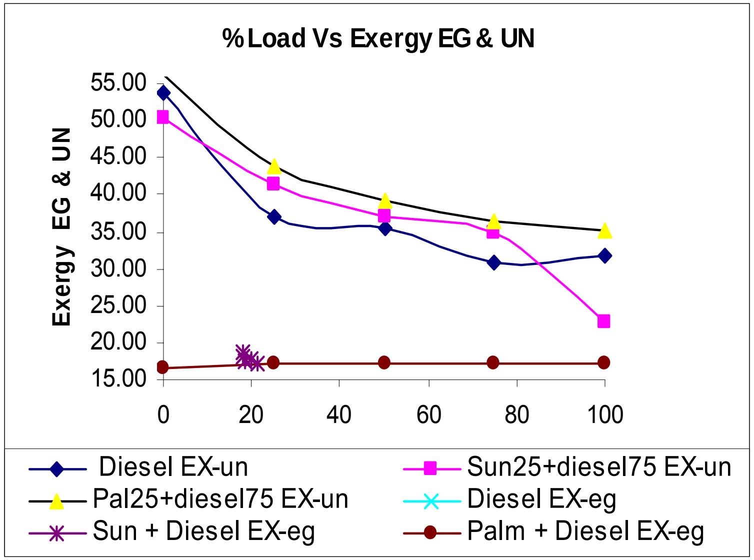
Fuel used	Mass flow rate of fuel kg/hr	Fuel Exergy supplied kJ/s	Exergy of BP kJ/s	Exergy of CW kJ/s	Exergy of EG kJ/s	Exergy unaccounted kJ/s
DIESEL	0.37	4.46	0.00	1.267813	0.800771	2.39
	0.47	5.67	0.91	1.602762	1.061979	2.09
	0.67	8.08	1.73	2.084563	1.410844	2.86
	0.82	9.89	2.58	2.484397	1.779976	3.05
	1.05	12.66	3.45	3.038084	2.173553	4.00
SUN FL0WER25%+ DIESEL75 %	0.36	4.22	0.00	1.260875	0.836838	2.12
	0.52	6.09	0.91	1.546313	1.108214	2.53
	0.70	8.20	1.73	1.926833	1.497705	3.05
	0.89	10.43	2.67	2.239564	1.871264	3.65
	0.94	11.01	3.45	2.735616	2.332718	2.50
PALM OiL25% + DIESEL75 %	0.39	4.57	0.00	1.244312	0.760806	2.56
	0.52	6.09	0.91	1.47874	1.041729	2.66
	0.71	8.32	1.76	1.859363	1.433869	3.27
	0.90	10.54	2.65	2.257023	1.809016	3.83
	1.10	12.89	3.46	2.688762	2.226543	4.51

ICAER-2007









ENERGY AND EXERGY ANALYSIS OF A DI-DIESEL ENGINE RUN WITH DIESEL - BIO LIQUID BLENDS

T.Ashokkumar, Dr.R.Chandramouli, D.Shanmugasundaram, T.K.Kandavel,Dr. K.Murugu Mohan Kumar SASTRA University Thanjavur

ICAER-2007

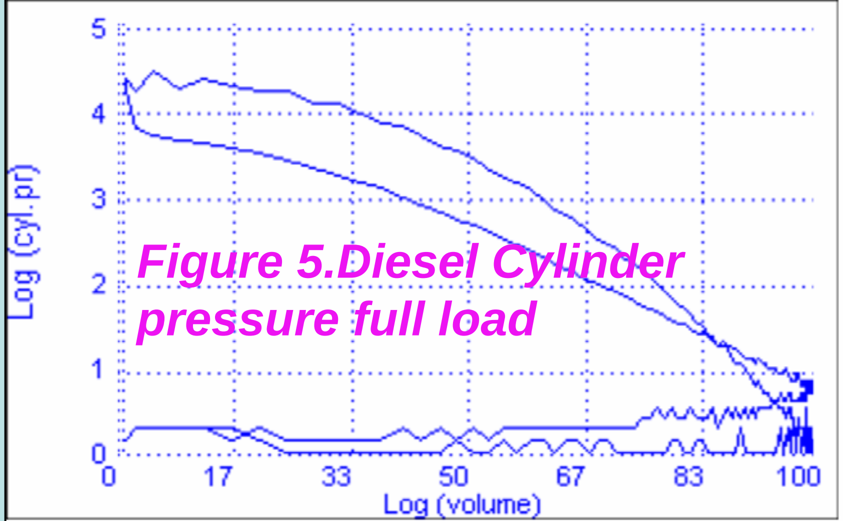


Figure 5.Diesel Cylinder pressure full load

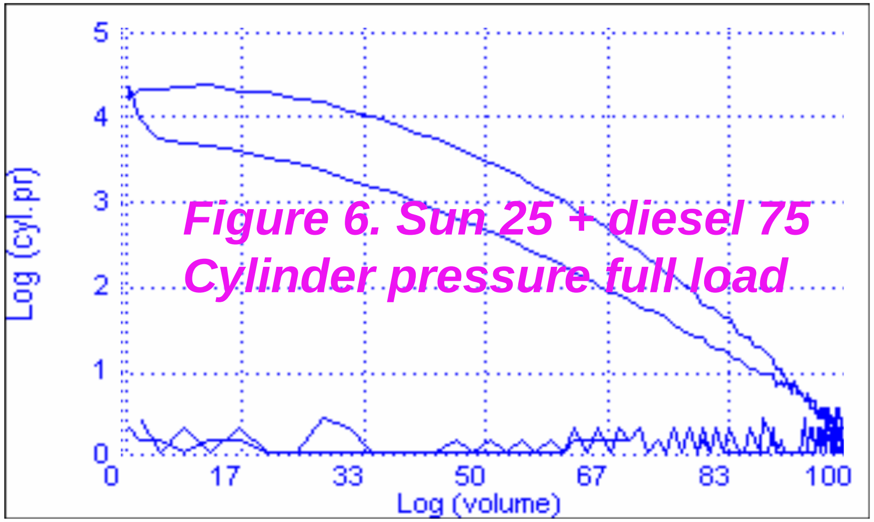


Figure 6. Sun 25 + diesel 75 Cylinder pressure full load

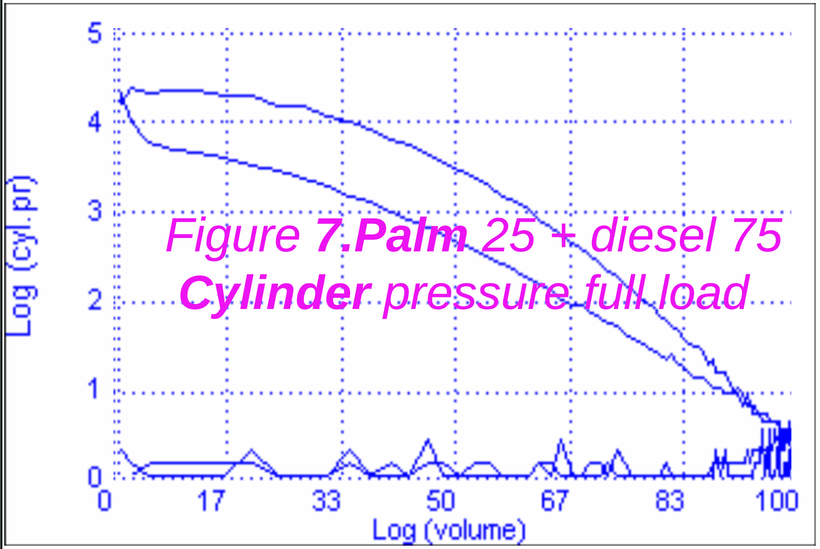


Figure 7.Palm 25 + diesel 75 Cylinder pressure full load

Figure 8. Diesel Mean gas temp. full load

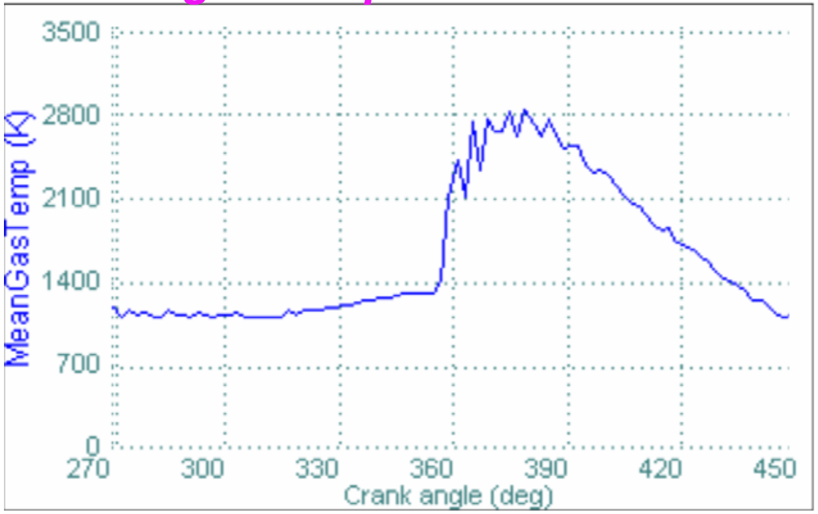


Figure 9. Sun 25 + diesel 75 Mean gas temp. full load

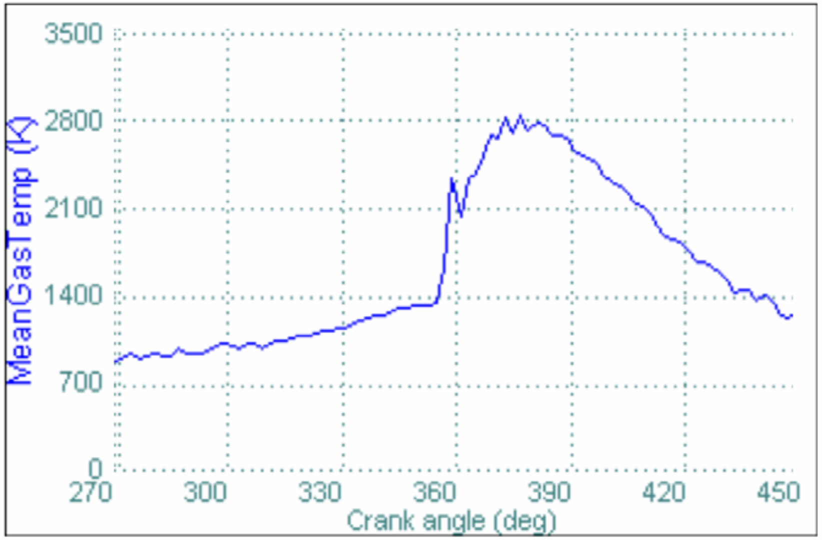
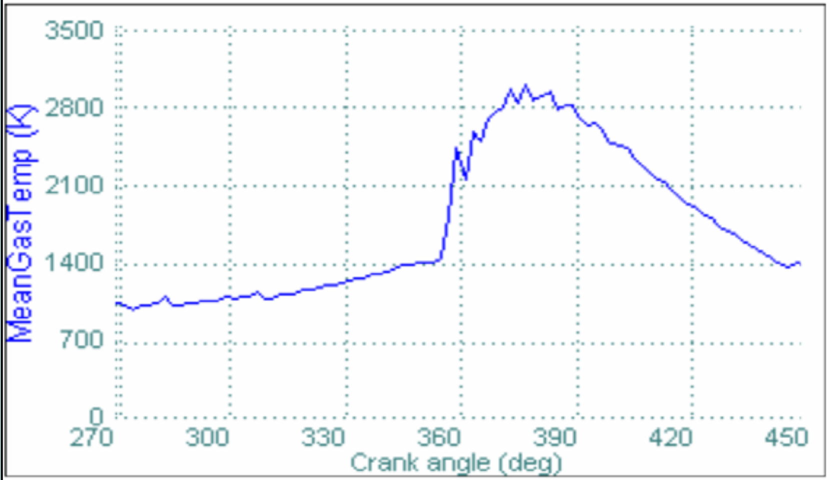


Figure10.Palm 25 + diesel 75 Mean gas temp full lo



I C A E R - 2 0 0 7

- The input fuel energy to the engine (Qin) is calculated by the First law of thermodynamics as fallowed:

$$Q_{in} = m_f * LHV \ \text{kJ/kg of fuel} \qquad (1)$$

[The LHV of diesel = 42000 kJ/kg of fuel , that of sunflower oil blended with diesel and palm oil blended with diesel is taken as 40800 kJ/kg of blended fuel for the test purpose.]

- Available energy supplied by the fuel is calculated by

$$A_{in} = 1.0338 * Q_{in} / (3600 * 42000) \ \text{kJ/s} \qquad (2)$$

- Heat carried by the cooling water is evaluated as:

$$Q_{cw} = m_{cw} C_{pw} (t_{2c} - t_{1c}) \ \text{kJ/s} \qquad (3)$$

- Available energy in cooling water:

$$A_{cw} = m_{cw} (C_{pw} ((t_{c2} - t_{c1}) - t_{c1} \ln (t_{c2}/t_{c1}))) \ \text{kJ/s} \qquad (4)$$

(the reference temp is taken as inlet temperature of water for AE in cooling water, air inlet temperature is taken for exhaust gas for calculating AE in exhaust gas)

I C A E R - 2 0 0 7

- Heat carried by ambient air:

$$Q_{air} = m_a \, c_{pa} \, t_{a1} \text{ kJ/s} \quad (5)$$

- Heat taken by the exhaust gas:

$$Q_{eg} = m_{eg} \, c_{p\text{-}eg} \, t_{eg} \text{ kJ/s} \quad (6)$$

- Entropy generated:

$$\Delta s \, eg = m_{eg} \, c_{pg} \ln(T_{eg}/T_a) \text{ kJ/s} \quad (7)$$

- Available energy in exhaust gas:

$$A_{eg} = Q_{air} + Q_{eg} - \Delta s \, eg \text{ kJ/s} \quad (8)$$

- Availability unaccounted is calculated as:

$$A_{un} = A_{in} - A_{bp} - A_{cw} - A_{eg} \text{ kJ/s} \quad (9)$$

Conclusions

- Exergy efficiency is less than the thermal efficiency
- The brake power of diesel-sunflower blend is much better than other fuel tested.
- At the full load operation both pure diesel fuel and sun flower oil - diesel blend gives almost same brake power. The sunflower oil - diesel blend gives higher value of brake thermal efficiency as well as indicated thermal efficiency compared to other two fuels tested.
- Further, its specific fuel consumption is lesser compared to diesel and palm oil - diesel blend.

ICAER-2007

- Even though the sun flower oil – diesel blend finds better suitability at full load operation, pure diesel fuel is very much suitable at part load operation.
- The possibility of extracting energy from the cooling water is very remote, as it has lower temperature.
- At this juncture, it is necessary to identify the way of exploitation of the available energy from the exhaust gases, as it exits with higher temperature.
- It is proposed to carry out the exergy analysis of the exhaust gases under different fuel blends in future in order to account for as it exits with higher temperature.

I
C
A
E
R
-
2
0
0
7

Thank You!